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The Challenges and Possible Solutions in Implementing Driverless Vehicle in Indian Perspective

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Abstract - *The term Autonomous (driverless) Vehicle refers to the ability of a vehicle to operate and navigate without the assistance of human beings. The purpose of this paper is to vehicle out a review and find the issues and the possible solutions regarding the implementation of Autonomous vehicles on India roads. The autonomous vehicles are our future, once implemented this can revolutionize our traffic management and transport system. This paper addresses some of the hurdles the technology might face in the country and offers a few measures that can be taken to overcome the downsides Also this paper reviews the methods of obstacle detection for autonomous vehicles and proposes the better approach in Indian perspective. The environment of India is different from rest of the world where automated vehicles are being implemented. The multi-sensor-based obstacle detection methods coupled with range finder and vision algorithms provides good for obstacle detection, velocity estimation of dynamic obstacles and estimation of rich semantics of obstacles. These are some of the factors for making an autonomous system to make intelligent decisions for planning and navigation. The aim of this paper provides a comprehensive overview and proposes a way forward as regards to the implementation of autonomous vehicles in Indian context.*

Key Words: driverless, navigate, image-processing, video-processing, autonomous, trajectory, etc.

1. INTRODUCTION

This Autonomous vehicles have been a dream of human beings since a long time. Today as we are inching towards a driverless future, the technology is getting increasingly developed over time. This was once considered as a science-fiction, but now is a reality. In the last couple of years, the autonomous vehicles technology has seen tremendous advancements. Many organizations have already deployed their own version of driverless vehicles on roads. In the Indian cities, especially the capital and other major cities, these are infamously renowned for their traffic jam. Not only traffic congestion is an everyday scenario in the country, traffic rules are seldom enforced properly. With non-standard roads, lack of proper lane facilities and broken traffic system, Indian cities are a nightmare for driverless vehicle progress. Despite these major concerns, it would be knave to write the prospects of this technology in a country like India. While the concerned authorities are taking many measures like constructing flyovers, roads, increasing the technology etc, but the issue is still likely to be persistent in the future given the increasing number of human and vehicle population. In order to make the automated vehicle work in real time environment another thing is the obstacle detection. Without an efficient obstacle detection, the whole system will collapse. With the help of the detected obstacles, environment models are designed and trajectory is planned for the navigation. Obstacles can be of two types, Static and Dynamic. Many approaches are used to detect the obstacles for example GPS and LIDAR in combination with other sensors.[1] LIDAR is a considered as a better approach. As its is proved good for detecting the objects efficiently also it works in any weather condition and makes segmentation process easy. Another approach for detecting the obstacles is extracting raw data from images and then following a feature extraction done by sending data into the classifier. [3] Convolutional Network is used for this approach along with back propagation algorithm. Multiple objects tracking and detection is done by many processes.[4]This approach uses the famous SLAM (Simultaneous Localization and Mapping) system. It is used for simultaneous localization and modeling of objects. Vehicle safety is also an element of competitiveness; therefore, vehicle manufacturers are paying much attention to this issue when developing new technologies. The modern vehicle is designed with particular emphasis to ensure a high level of safety of the stakeholders and other users. [5]This paper reviews the different approaches and proposes the best approach that can be used to detect the obstacles in India's environment, for increased operation ability and efficiency where traffic rules are not followed as strictly as in other countries. The method is basically used for automated vehicles but can also be applied in other vehicles to warn the system from unexpected obstacles and can guide driver to follow a good trajectory. It can also be very helpful in avoiding accidents in India.[8]In this paper, there are some proposals that can be implemented to mitigate the gap between Indian roads and the roads of the countries where autonomous vehicles are already implemented.

2. LITERATURE SURVEY

The issues of the Indian roads are highlighted in various periodicals published by many international agencies. According to them the Indian roads are filled with the non-motorized vehicle that often create hindrance on the roads. [11]The concern of pedestrian overcoming and over involvement of the large vehicles are among the other issues the paper mentioned. Proposed that most of the traffic congestion in is caused by mainly three issues: irregular vehicle docking, street hawkers and pedestrian on the roads. Proposed that issue that might become problematic for driverless vehicles in India is that of the bad roads filled with pot-holes. [9]While all these problems can be solved with the proper infrastructure improvisation, the concern of traffic mismanagement and lack of enforcement of traffic rules remain to be the main problem in the country regarding the transportation system. [8]A major breakthrough in the field of autonomous vehicles system came with the inception of modern electric technology from makers like Tesla and the introduction of their Autopilot system.[3] Autopilot system can substitute the role of a human driver and operate the vehicle under various circumstances. In order to develop a robust real time system, we need to understand scenario in context of automated vehicle. At first, the vehicle has to localize itself that where on earth it is located. To locate the vehicle, we must have to make models of environment by using obstacle detection. [5]Most of environment models are not adaptive to change, i.e. those models cannot grasp the change in the environment and cannot do planning and control effectively when new kinds of obstacles are introduced at the run time. This problem was solved by using reverse optical flow.

Another proposed approach, was that the road markers were not used to identify regions of road. While the roads can be ill-structured, as in many areas of India. [4]In that scenario Ramussen presents a new approach, instead of locating road markers this approach looks for the obstacles, left on roadway by vehicles, but these marks can get erased due to the rain or wind storms etc. By using reverse optical flow algorithm, it is assumed that automated vehicle is currently on the road and from previously stored data it matches the current image with previous one to make a new road map at real time. [11]This process continues and with the help of self-supervised learning and therefore system adapts new changes in environment.
Another approach that is becoming famous in the recent years is that of the vision center approach. In vision center approach, here the camera images are used to identify the obstacles. Many methods in which stereo pair cameras and monocular cameras were used to detect obstacles in real time and it also helped in overcoming issue of occlusion handling. Another approach in which whole dynamic scene is captured and modeled instead of tracking and segmenting individual objects, was presented by Qingtuan Li and Liang Zhang. In their method, whole dynamic scene is tracked as one motion field. Every dynamic obstacle is considered. Over the past many years, some vehicle safety requirements have been introduced as mandatory. The protection of vehicle during the front and back impression, as well as the much-needed pedestrian protection, was considered to be key in terms of the norm of regulatory intervention in vehicle safety. This action has widely contributed to reduction of the number of traffic accidents and deaths / injuries.[6][8]There is nothing like unobserved data. It is said that the autonomous vehicle industry will only get bigger from here one. According to Uber - the autonomous vehicle is expected to replace at least10 million jobs and have a major impact on the country's economy. These were possible by the growth of Machine Learning and Artificial Intelligence in the last decades. Path-planning is one of the most important primitive modules for autonomous mobile vehicle that lets them to find out the shortest or otherwise optimal path between two points. [1]Otherwise optimal paths could be paths that minimize the amount of turning, the amount of braking or whatever a specific application requires Edge detection includes aims at the of mathematical methods that focus on identifying the required specific points and the locations in a digital image at which the image brightness varies exponentially or, in other parlance formally, has some discontinuities. The points at which image the characteristics and brightness changes sharply are typically organized into a few sets of curved line segments and trimmed as the edges. The similar problem of identifying the overall discontinuities present in the one-dimensional signals is termed as step detection method and the problem of detecting the signal discontinuities over the time is known as the change detection. [2]Computer hardware makers like Nvidia are now approaching with their AI powered computer platform dedicated to the autonomous vehicles. The Nvidia PX can detect the surroundings precisely in a fraction of time.

3. CONSTRAINTS AND ISSUES

3.1 CONGESTED ROADS AND DOCKING

The cities and the towns of India are one of the most densely populated in the world, the traffic jam situation in the country is very alarming. Even when it's not busy hour, the roads in the cities will be filled with vehicles movements. The situation gets worse as the vehicles do not follow traffic regulations. The drivers try to congest the space by putting their vehicles as close to others as it may be possible. So, when there's a green light, it takes the vehicle more time to get itself out of the cramped space and move ahead, resulting in more traffic congestion. There is also an undefined territory for today's autonomous vehicles. The system will need proper modification to

adjust to such wary conditions. Unlike most developed countries, India lacks the proper docking spots in the country. Most drivers will try to dock their vehicles in the streets, blocking the steady flow of traffic. A sour autonomous vehicle needs to park at its destination, it must have prior information about designated parking spots. India roads will become a hard nut to crack for autonomous vehicles in this regard.

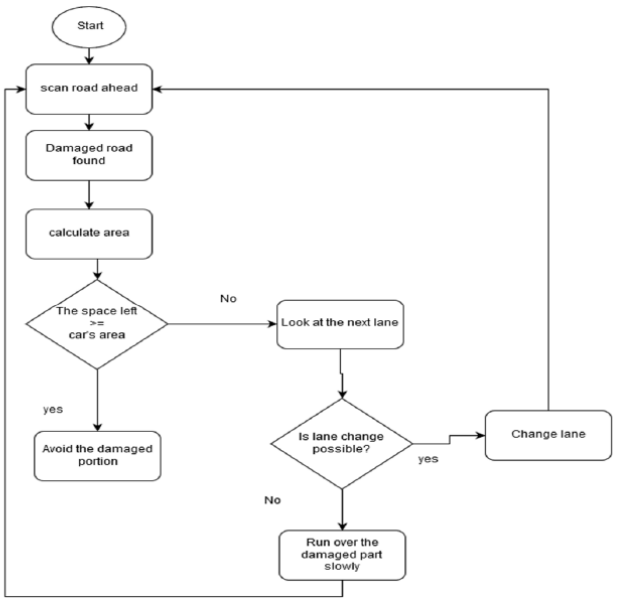

Fig 1-: Collision avoidance system.

3.2 DISRUPTED ROADS AND TRAFFIC CONTROL

Many roads and driveways in Indian cities are the victim of water logging issues. As result, of this the roads get broken and disrupted after a few months of operation, leaving potholes and fractured spots. The drivers in the country often change their lanes, and also brake unexpectedly to avoid running over these spots. This is problematic for the current vehicles since they are not used to these types of roads. The vehicles might run over these spots and cause damage to it and its passenger in the process.[4] Not to mention the overall unexpected lane changing and sudden braking might confuse the vehicle that could lead to the accidents. Although the authorities have tried to enforce automatic traffic control several times in the past few years, the huge traffic and the inconsistency made it difficult to maintain an automated system. Almost every traffic section in the cities is controlled by traffic administrators manually. They use the hand signals and voice in order to control the traffic. [7] This is very difficult for a driverless vehicle to comprehend unless a proper alteration is made to the said area. If the wagon is deep in the queue, it becomes inferior for the vehicle to understand traffic.

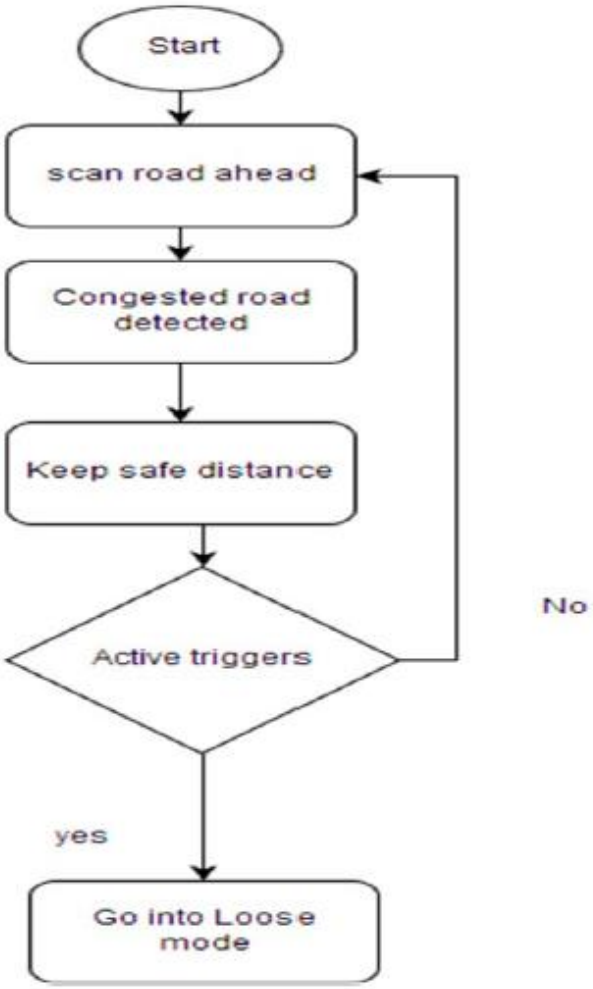

Fig 2 -: Loose mode initiation

3.3 MANUAL TRAFFIC CONTROL AND LANE MANAGEMENT

Most autonomous vehicles that are in deployment today change lane diligently and efficiently if required. But their ability is untested in an adverse situation like that of the Indian roads. Most vehicles in the country do not maintain proper lanes. The vehicles are all over the road despite there being laws against it. This is in particularly tricky situation for an autonomous vehicle to comprehend. Current autonomous vehicles are designed to oblige sincerely to the lane maintenance rules in the streets/roads. But when almost every other vehicle is breaking the rules, it becomes harder for the vehicle to be the only one abiding the rule. In the recent years the government has tried to enforce the automatic traffic control modalities several times in the past few years, the huge amount of traffic and the irregularity has made it difficult to maintain an complete automated system.

Virtually each traffic section in the cities is operated and controlled by the traffic officials manually. They make use of the hand gestures and voice in order to control the traffic flow. This is now becoming quite tedious task as an autonomous vehicle to comprehend unless a proper calibration is made on the defined area. If the vehicle is deep in the line queue, it then becomes much worse for it to understand the traffic signal.

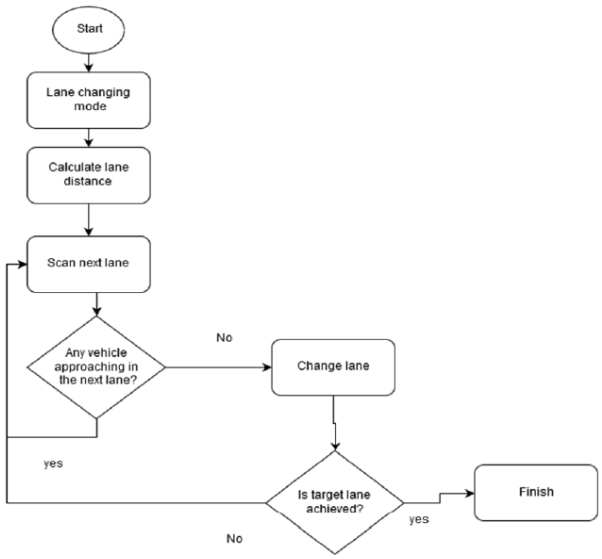

Fig 3-: Mechanism for lane changing.

4. METHODS FOR THE OBSTACLE DETECTION

4.1 USING THE POSE ESTIMATION

For an automated vehicle to run safely in a constrained urban environment, it is mandatory to predict the motion of dynamic obstacles that come in front of it. This is done by pose estimation. In the 3D coordinates vehicle's pose means vehicle's 3D coordinates and its governing orientation. This is called as the six degree of freedom. For the efficient pose estimation system data from multiple sensors is combined to get a model of environment. LIDAR data in fusion with camera images, proved to be a good combination for providing efficient solution of the given problem. In this method pose of obstacles are identified using the Extended Kalman Filter (EKM). Data is acquired using the LIDAR and monocular camera. This method does not use Global Positioning System (GPS) as seen in the conventional systems. Features are then initialized using data acquired from 3D laser scans and visual images. Temporary feature maps are used instead of a full 3D laser scans to reduce the computational cost.

4.2 CLUSTER VEHICLE TARGET TRACKING USING THE LIDAR

In this method we will confer vehicle like target tracking based on the LIDAR. Two approaches are fused to get the target. One is the widely used Multiple Hypothesis Tracking MHT Algorithm and second one is the Dynamic Point Cloud Registration. DPCR is used to find out the pose motion whereas MHT simultaneously track vehicle like objects.

This method is used to find out the pose of an automated vehicle. And GPS and IMU is used. This is done by translating the raw data from moving coordinates to static coordinates. MHT is used to improve performance of DPCR. MHT removes dynamic points from the image. In the case of dense traffic situations, it becomes necessary to track many dynamic obstacles at the runtime. MHT can be used as the best approach in those cases. In order to consistently track obstacles, data must be transferred into its corresponding static coordinates.

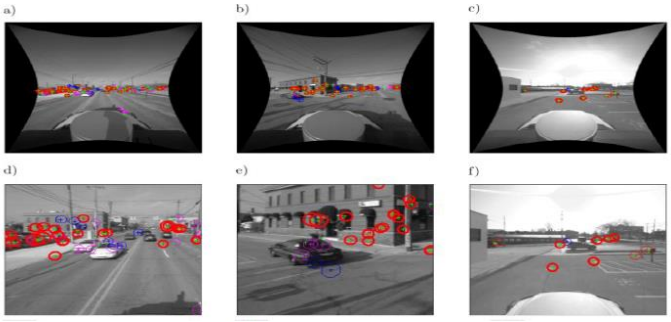

Fig 4-: Vehicle Cluster Tracking.

4.3 POSE ESTIMATION USING THE SINGLE-TRACK MODEL

In this method we use the combination of sensor data and the LBA (Local visual Bundle Adjustment). It defines that the pose is observed with respect to one vehicle and images are observed by sensor mounted in the vehicle. Pose estimation is useful in making "augmented imagery. It means fusing of the virtual objects with real images. This is useful in tracking of dynamic obstacles and map the corresponding constructions. It is important to find pose of camera accurately as in case of a small error can result into significant loss. Structure from Motion (SfM) approach is used in this method. It means use an image sensor for pose estimation and make the structures of environment again with respect to image.

4.4 USING THE NEURAL NETWORKS

The use of the neural networks proved to be a good method in many areas where detection need to be done. For example, take the case of face recognition, digit

classification, image processing etc. It extracts features from pixel level from the data. It relies on data sets and back propagation method in order to identify a particular obstacle. It is used with gradient descent. It works on the principal that learning is done by adjusting weights according to the desired output. Features are extracted from raw data and then sent to classifier to classify type of obstacle. It needs large training sets for providing good results as in the environment.

4.5 SEGMENTATION BASED ON REAL TIME ENVIRONMENT

In this method the live data of RGB-D image is taken as the input. Objects are tracked and segmented from this input data in the 3D shape and this process continues in real-time. Objects are tracked and the 3D models are made at the same time. While dealing with dynamic scenes moving scenes are discriminated. Therefore, their shapes cannot be tracked with respect to time. In this method objects can be segmented with time, which enables efficient handling of dynamic scenes. Multiple model approach is used to track different objects and these objects can be distinguished easily from the background.

4.6 METHODS COMPARISION

This section aims at finding out the best method as in the case of detection in the Indian context.

LIDAR gives good results as compared to camera as it provides depth of the information of image and not effected by the prevailing weather conditions and also has no effect of the distance. In case of stand-alone camera use, image gets distorted because of distance. When image gets distorted, then the pose estimation and tracking cannot be done with precision. Depth information of image is taken in a better way with the use of LIDAR based approach. It also proved good for eliminating the effect of "phantom obstacles". On other hand when using LIDAR with MHT and dynamic point could registration, it results in occlusion in some cases.

As mentioned in some methods the dynamic obstacle detection is done by discriminating dynamic data points from a set of data and then treating the rest of the data as a mere static data point. Such kind of tracking does not help in identifying shapes of the obstacles. A better approach is presented in method discussed in Co-Fusion method, which describes about enabling a system to make 3D models for segmented objects which can help in overcoming this issue by separating background from the foreground. System can make object level description and hence improves in dealing with dynamic environment. In some of the methods we have discussed, unknown objects are treated as out liars whereas co-fusion methods detect the unknown objects too and 3D models of unknown objects are also made to work at run-time. Multiple Target tracking using LIDAR method emphasize much on the multiple targets. A better approach using LIDAR is tracking whole dynamic scene as a motion field. All methods in which segmentations and data association need to be done before tracking cannot afford any error in segmentation or in the data association.

5. PROBABLE SOLUTIONS FOR THE ISSUES

In this section we discuss some of the possible solutions for the successful implementation of autonomous vehicles in India. Considering the issues prevalent we first need to design the computing architecture for the vehicle particularly aiming at the autonomous driving module and the obstacle detection. Here we consider using an SoC that is capable of exchanging data with the sensors and fast enough for calculate huge chunk of data per second. Since the vehicle will use machine learning, it requires heavy parallel computing power, for that reason, the CPU will be accompanied with a more powerful GPU. The Vehicle will be controlled by motor controller, capable of reading its rotational speed and rotate the wheel 180 degrees. One of the front cameras is capable of infrared imaging, they will be placed in such a way that a complete stereoscopic 3D image of the real-time environment can be formed. Each side is armed with a proximity sensor to detect other objects' distance. This along with the infrared sensor will make sure objects are identified no matter the situation. The SONAR sensor is also stereoscopic. They can read the depth and magnitudes of any surrounding objects. There are other sensors like GPS and accelerometer; they will help determine the location and position of the vehicle. The Vehicle is powered by an electric mechanical in the back with PWM competence. An array of battery system is powering the motor and can be charged fast with the home mains.

5.1 ADDRESSING THE DISRUPTED ROAD PROBLEM

The vehicle will deal with broken roads by using any blends of the total avoidance and/or slow run over in damaged streets. The Vehicle will first detect a dented area by using its front camera and its infrared and Sonar capabilities. Once detected, the Vehicle will make use of its virtual rectangle of the damaged part so that the rectangle contains the damaged portion in its vicinity. The Vehicle will then calculate the amount of space left in current lane, if there's enough space for it to move through, the Vehicle will avoid the potholes. If it's not the case, there are two possible outcomes. The Vehicle will either Vehicle out the alteration of its lane or run over the area with causing as fewer damages possible by slowing down its speed.

5.2 NAVIGATION IN DENSE AREA

On its roll and flare, the Vehicle start cramping up as much as possible. Our Vehicle's goal is to keep its safe distance from other Vehicle until the following triggers are executed. The triggers being: Vehicle in the back asking for space, people using voice or hand gestures to let their Vehicle go. One of the ways our Vehicle will detect this is by arbitrating the amount of space in front of it with the approaching of that Vehicle and/or rate of its honking. This is so-called "Loose mode" where the Vehicle will act against its regular will and cramp up space like other Vehicle. In this situation, the Vehicle will use its proximity sensors, cameras and sonar sensors to detect whether it's in a congested place. As for human gesture recognition and voice detection, the Vehicle will use its microphone, camera(s) with the natural language processing and image recognition system.

5.3 LANE ROUTING

The lane routing is an important aspect of any automated vehicle. The combination of the following triggers is detected: Vehicle needs to speed up but is in a slower lane, the Vehicle needs to slow down and is in a faster lane and when the Vehicle is in the wrong lane and needs to stop. The Vehicle will first determine the lane it wants to switch to. It will then compute the lane distance and cutback the distance with each lane switch. The Vehicle will only switch lane if no vehicle in the targeted lane is approaching or has any chance of being while the Vehicle is changing lane. It will also determine whether lane changing is allowed in the street. If these conditions are met, the Vehicle will continue to change its lane until the target lane is successfully navigated.

5.4 VEHICLE STATIONING

Since parking is an important element in any design of the vehicle. The vehicle needs to be in the parking mode for this to work. Parking mode is activated when the vehicle needs to stop for an emergency, or if it has arrived at the destination or is asked by the user to stop. In this mode, the vehicle will look for chosen parking spots in the area, if no such area found, the vehicle will go in to "Loose parking mode." In this state, it will look for an extension of the road that might be a potential parking spot. If the width of the leeway is equal or bigger than the vehicle's width, it will park itself in the spot, provided it's free. How long it will stay in the spot depends on user's return and spot's possession

6. CONCLUSIONS

Autonomous vehicles have the potential to become the permanent solution to India's infamous traffic problem. Based upon the comparison of reviewed methods, we come up to the conclusions that for making a robust autonomous vehicle in environments like India the above discussed methods are more feasible than others. Concluding our reviews, we suggest that LIDAR in fusion with other vision sensors can be proved to be a viable option for gathering the precise information about dynamic obstacles, which is mandatory for making a robust self-driving vehicle. Our comparison measures are mainly center around data acquisition with precision, computational cost, the degree of freedom, real time tracking and segmentation and handling the complex scenarios. In this paper, we have tried to achieve just that by finding out the issues and possible solutions. Notwithstanding our limitations like not having an actual autonomous vehicle and lack of funding for building a prototype, we believe our study is a good path forward for other researchers to follow. The necessary adjustments are made by observing our simulations. If the simulations are any indications, it will be possible to build a prototype on this that will work on Indian roads. With proper implementation and adjustment, India can also take part in this driverless vehicle revolution that would eventually result in achieving the dream of becoming a technology driven country.

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